States as Game Players The Example of Russia, China and Europe

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Since the publicationof "The Theory of Gamesand Economic Behavior" by vonNeumannandMorgenstern(1944), game theoryenriches theunderstandingof international relationships.However, toooften, at this international,the applicationof this theoryislimited tomilitary concerns andvery few to global strategic views that understand togethereconomy, tradeand finance, as well as cooperation amongStates.However,since the Cold War end,the emergence of newcountriesin South-East Asia, the BRICS, preserving economic interestsinvolves using newinstruments such asfinancial flows, monetary exchange rates,interest ratepolicy,R& D, space policy, trade agreements, etc. This arsenalis deployed withthe objective of ensuringprosperity andstability of Statesand notpermanently destroysan opponent.During the Cold War, the East and West blocks struggled one against the other one like twoSumo wrestlersortwochess players.Nowadays, multi-polarity rules a game characterized by complexity. Indeed, following their short terms or long term interests the States can become simultaneously partners or adversaries (see for instance, Evans, Graham and Newnham,Jeffrey (1998)).

Then, how to model this multi-polarization of relations between states? The issue is even more complex than, according to circumstances the States are mutually sometimes partners and sometimes opponents (Evans, Graham and Newnham, Jeffrey (1998)). Facing with these developments, the States both have to preserve their interest and conquer new opportunities by using strategies that come more from the Go game (Weiqi in Chinese) than Chess. In a Go game, the world becomes a global space and the purpose it is to occupy the greatest surface by the placement and the supportive positioning of pegs (called stones) on the junction of transverse lines. The winner occupies the largest area of the game. This Chinese old-art game belonged to the military aristocracy close to the Emperor and was the only one allowed playing. It is in the spirit of GO game that we develop this study that focus on relations between different states. We show how they differentiate from standard players of usual game theory. This approach is a first attempt to characterize the strategic interrelationships between multiple players-states. Here, it will be limited to the inclusion of three players and not only two as usual. This extension does not result in the simple increase of the strategies possibilities, but can also lead to a structural change of the agents' payoff functions. Indeed, for strategic reasons related to past mutual agreements, a given State may have interest in increasing the wealth of some of its partners compared to those of some of its opponents. This, of course, greatly enriches the range of possible and helps modifying the impact of strategies based on threats and promises.

1. Characterization of games between States and sequential choice of strategies

With players such as governments or institutions, the rationality of choice and game structure is quite different from the standard structures on which we build the game theory 'standard' models. Obviously the deep nature of the game is quite similar to these ones so that we can legitimately consider that the games we describe belong to the bargaining games (Nash (1950) and (1953)).

In concrete economies when speaking about governments, information arrivessequentially and the strategic choices supplied toplayers are common knowledge. A game in whicheach playerdiscoversthe strategy chosen bythe othersand plays simultaneously is nosense in thiscontext (Brams(1994), Stone (2001)). The implications ofthis findingare important.In particular, itmeans thatthe games fullinformation games that each player play sequentially andknowswhat the otherplayer has played. Schelling (1960) showed that normal orstrategic formgames do notreach the same solutionsfollowing they are played simultaneously or sequentially. This can besimplyillustratedbythegamesin Figures 1 and2. Thefirstgameisanincomplete information game.Both players1 and 2 mustchoose either theL orRstrategies. Inincomplete information, Nash equilibriaof this gameare(L,L), (R,R) orthe mixed strategy(1/6L+5/6R)for Player 1, (5/6L+ 1 /6.A) for player2. Theexpected gainin the caseof amixed strategyis then 1for each.The treeof this game istranscribed inFigure 1.

If we considera sequentialgame, where player 1plays first, this one benefits of aclear advantage. Indeed, heplaysthestrategyL which forcesplayer2 to playthe strategyL. We say “force”because, player 2 could threat player 1 to play R, to force player 1 to change his strategy and playing R. However, as a rationalbeingplayer 2 cannotcarry out histhreat, hewill prefer toearn1rather than 0. Hence, the equilibrium of the game is (L,L).

Figure1

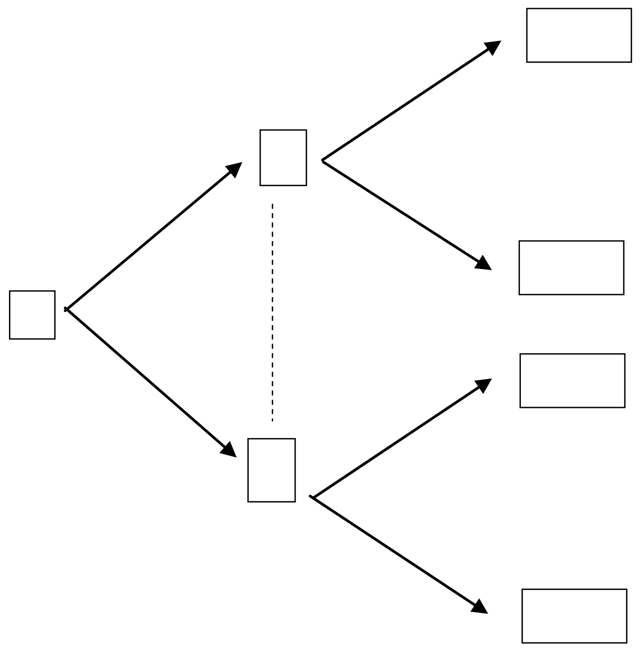
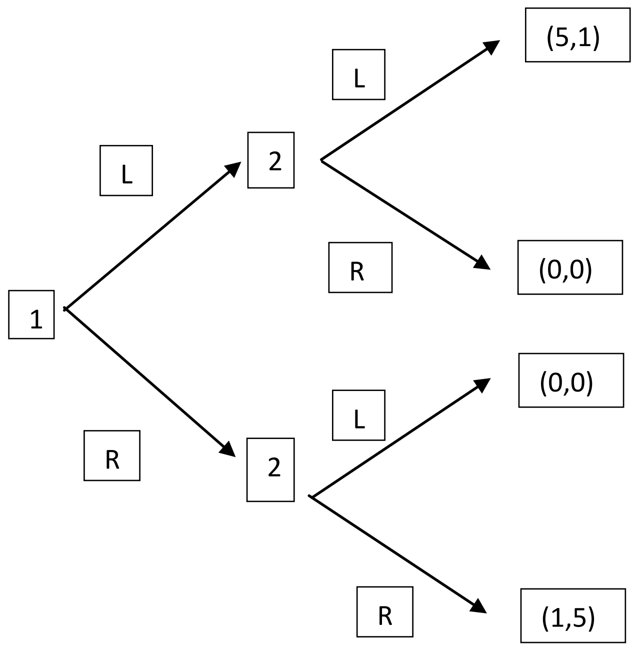


Figure 2



A. A three-players threat game

Considering that three states (States 1,2,3) exchange together, that they maintain bilateral relations and that each one plays their strategies sequentially. This means that the order of the strategies choice is important. In the game bilateral relationships are described by pairs {(1,2), (2,3), (3,1)}, the first player chooses first his strategy (in the pair (a, b), a chooses first then b). In this three-player game, by assumption, each player knows his own payoff functions and the one of the other ones. The game is a full and perfect information game and it is described in Figure 3. The States adopt strategies of conquest and preservation of their interests falling over the strategy of the game of GO (Weiqi in Chinese) than chess. In this game, the world becomes a space for it to occupy the greater part by the placement and positioning of pieces (called stones) on a supporting organization. This is made by putting them on the junction of transverse lines.Is declared the winner the one who occupies the largest area of the game. This millennial game (should say art) is Chinese in origin and only close military aristocracy of the emperor was allowed to play. It is in this spirit that we will develop our study of relations between different States corresponding to players. The question that arises is how to model the multi-polarization of relations between States? The issue is even more complex that they are, depending on the circumstances, mutually partners and opponents. Evans, Graham and Newnham, Jeffrey (1998).

B. Equilibrium of the game without prior agreement.

The game described in Figure 3 can be analyzed as a sequential game that can be subdivided into three subsets: (1,2), (2,3) and (3,1) because the balances are made independent of each other. This results from the fact that players do not agree at the start of the game. No binding agreement, any agreement or cooperation is assumed. One can notice the similarity of the structures of the first two ((1,2),(2,3)), which allows the same treatment.

a) SubgamesEquilibrium (1,2), (2,3)

The two sub-games are threat games. In the game (1.2), 2 threatens to play d_1, that brings him 5 and 0 to player 1 if this last one does not play a_1. The latter strategy will make him win 7 against 1 to player 2.Player-1 understands that the threat is credible because if he chooses b_1, it has no way to induce the player to play two c_1 strategy that brings back him 2. The equilibrium strategy is:

- $S^*_{(1,2)} = (a_1)$, and the associated gainsforboth players:

$$g_{(1,2)} = \big(g_1(a_1), g_2(a_1)\big) = (1,7)$$

About the game (2.3) the threat is not credible. Indeed, 3 threatens to play d_2 if 2 does not play a_2. Now if 2 overrides, he will win 2 because the player 3 will be forced to play the strategy c_2 and earns 3, whereas if he played the $d_2$strategy, he would only gain 2. Therefore, the threat is not credible and equilibrium strategy $S^*_{(2,3)} = (b_2, c_2)$will earn:

$$g_{(2,3)} = \big(g_1(b_2, c_2), g_2(b_2, c_2)\big) = (2,3)$$

b) Equilibrium of thesubgame(3,1)

In this game, the player 3 has theability to play the strategya_3, consequently the player 1 makesa gain0, or 3 can playb_3,inducing 1 to access to the payoff7. Let us note that inboth cases, player 3earns the sameamount: 4.This equilibrium isspecificas it givesthe opportunityto 3 to be apetty anddictatorialplayer by prohibiting 1 to gain 7 or to be generous, allowing him to get 7 by playing the to be3or(he playsthe$a_3$strategydeprivesplayer 1of any gain. or, conversely, liberalstrategy (b_3, e_3).

Thisthree-player gameis trivialandits only interestis that it helps to extend the argument to three effectively interdependent players. Note alsothatthe sequential natureof these gamesexcludes anyuse of mixedstrategies.The equilibriumsolutionsare purestrategies.

2. Game Equilibrium and prior cooperation agreement.

The game described above would be of little interest if the players keep isolated and play independently of each other. We assume now that some players conclude cooperation agreements with each other as it happens in the framework of effective international relations. For instance, here, we consider that player 1 and player 3 establish a long run cooperation agreement (as energy delivery, technology transfer, trade agreements…) so that a breach in the relationship leads both to significant losses and retaliation to which neither of them has interest. In our model, this agreement affects the agents' payoff functions that are both sensitive to the chosen strategy and theother agents' earnings. Thus, for each countryforming mutually binding agreements, each one will be careful to its partner's prosperity. Therefore, one might think that the growth of the partner's wealth brings it a higher level of satisfaction. Indeed, the partner becomes more solvent and that bodes new exchange phases. However, if we think in hegemony terms, the partners may consider that beyond a given threshold, cooperation may become harmful. To take this into account, one can consider a concavity in the payoff function. That means that beyond a given level of the partner's enrichment, the country would suffer a diminishing marginal utility. To do this, we consider that the agents' satisfaction functions depend on$U_j\,(g_{1,}g_{2,}g_3)$,$j = \{1,2,3\}$ gain of 3 players (indexed by j) are "standard" and if g_j represents the gain of player j, $j = 1,2,3$. This gain is associated with the adoption of a strategy S_j such that:

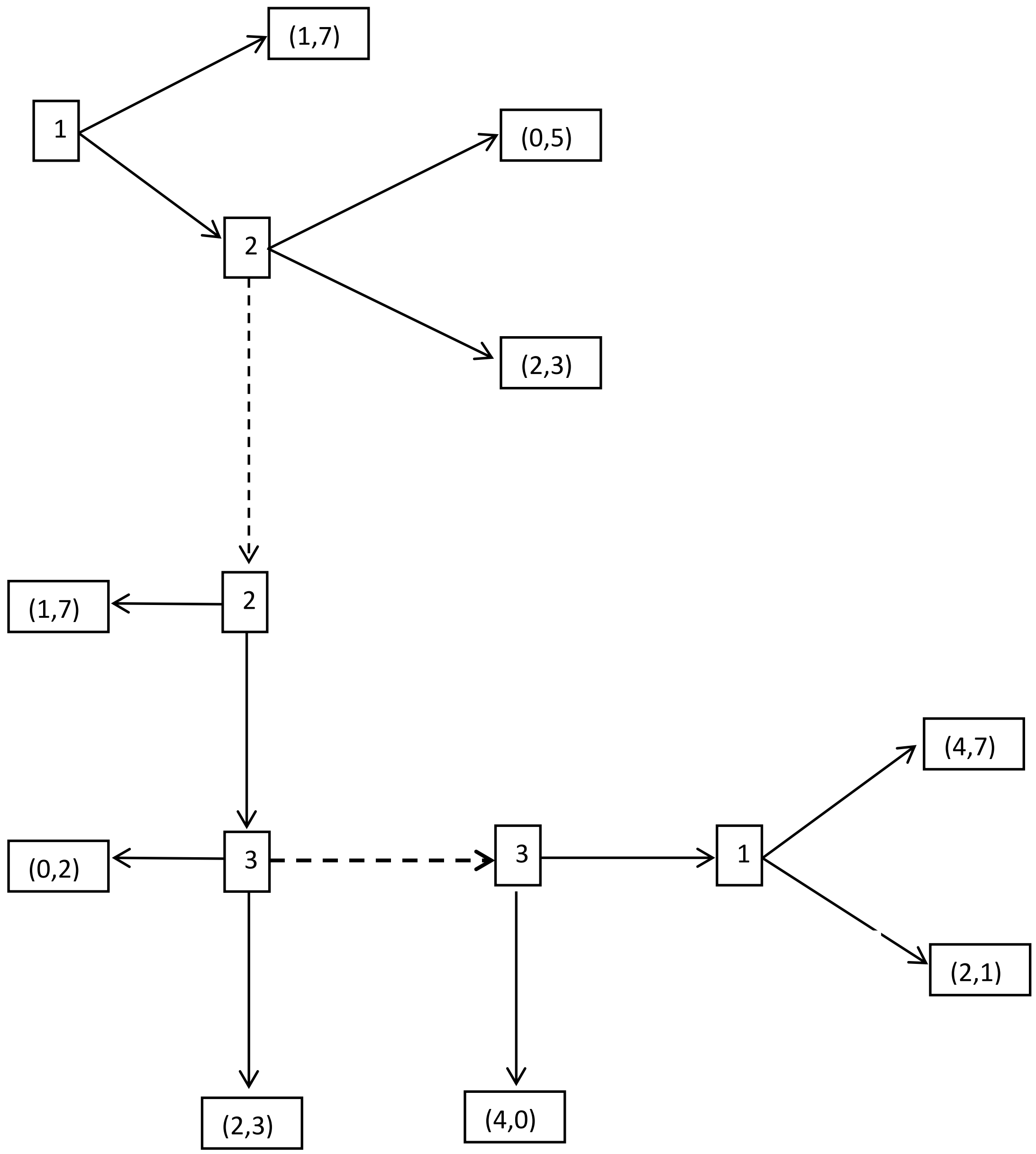
$$U_j\,(g_1(S_1), g_2(S_2), g_3(S_3))$$

In the standard case, the agent is attentive to its own gains and the expression above can be rewritten:

$$U_j\left(g_j\,(S_j)\right) = U_j\,(S_j)$$

Let's assume that, in our example, 1 and 3 players-States decide to cooperate. This cooperation led to the following expressions: $U'_{1g_1}(g_1, g_2, g_3) > 0$ and, $U'_{1g_3}(g_1, g_2, g_3) > 0$, which reflects the interest of player 1 to player 3 with $U''_{1g_3g_3}(g_1, g_2, g_3) \leq 0$. Concavity means that above a certain level of player's 3 gain, player 1 experiences inconvenience or it may consider that its position may be threatened by player 3. Similarly, for the player-State 3: $U'_{3g_3}(g_1, g_2, g_3) > 0$et $U'_{3g_1}(g_1, g_2, g_3) > 0$, with $U''_{3g_1g_1}(g_1, g_2, g_3) \leq 0$. This means that there is interdependence between the different players {1,2,3} and this fact opens the way to several scenarios and, as such, to several possible equilibria.

Figure 3



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Scenario 1

This scenariodraws the consequencesof above mentioned behavioralassumptions.Thegame equilibrium without prior agreementare maintained.The only notablepoint isthat, nowin the game between players 3 and 1 (i.e.(3.1)), Player 3 preferschoosingthe$b_3$strategy that ensures toPlayer 1a payoff of7rather than0 ifPlayer 1had playeda_3. Indeed,given ourassumptions:

$$U_3\big(g_1(S_1), g_2(S_2), g_3(S_3)\big) = U_3(4, g_2(.), 0) < U_3(4, g_2(.), 7)$$

The script,however,can complicatedif it turns outthat thecoalition formed by the Cooperation Agreementbetween 1 and 3is accompaniedbytheir mutual satisfaction of seeingPlayer 2's payoffrestricted.Scenario 2 studiesthis point.

Scenario 2

To the previousassumptions,

- $U'_{1g_1}(g_1, g_2, g_3) > 0$ et, $U'_{1g_3}(g_1, g_2, g_3) > 0$, et
- $U'_{3g_3}(g_1, g_2, g_3) > 0$et $U'_{3g_1}(g_1, g_2, g_3) > 0$,

Weaddthat :

- $U'_{1g_2}(g_1, g_2, g_3) \leq 0$et $U'_{3g_2}(g_1, g_2, g_3) \leq 0$.

That means that the rise in the Player 2's gain decreases the level of satisfaction of both Players 1 and 3.

That means that under this scenario, Player 3 is conditioning the play of its favorable and generous strategy towards Player 1 (i.e. (b_3, e_3)) to the obligation not to yield to threats that is, however, perfectly credible. In this case, and it is the core of the paper, Player 1 and 3 have convergent interests in their purpose of lowering the Player-2's payoff. In this case the equilibrium strategy becomes:

$$S_E^* = \big((b_1, d_1)\,, (b_2, c_2), (b_3, e_3)\big)$$

This involves the following payoffs for each player:

$$G_1(S_E^*) = g_{1(1,2)} + g_{1(3,1)} = g_1(b_1, d_1) + \ g_1(b_3, e_3) = 0 + 7 = 7$$
$$G_2(S_E^*) = g_{2(1,2)} + g_{2(2,3)} = g_2(b_1, d_1) + \ g_2(b_2, c_2) = 5 + 3 = 8$$
$$G_3(S_E^*) = g_{3(2,3)} + g_{3(3,1)} = g_3(b_2, c_2) + \ g_3(b_3, e_3) = 3 + 4 = 7$$

Remark 1

One point especially worthy of note is that with or without prior agreement between players 1 and 3, the Player-3's payoffs are identical. Indeed, one can check that without this agreement the payoffs are:

$$G_1 = g_{1(1,2)} + g_{1(3,1)} = g_1(a_1) + g_1(a_3) = 1 + 0 = 1$$

(Or,$G_1 = g_{1(1,2)} + g_{1(3,1)} = g_1(a_1) + g_1(b_3, e_3) = 1 + 7 = 8$)

$$G_2 = g_{2(1,2)} + g_{2(2,3)} = g_2(a_1) + g_2(b_2, c_2) = 7 + 3 = 10$$

$$G_3 = g_{3(2,3)} + g_{3(3,1)} = g_3(b_2, c_2) + g_{31}(b_3, e_3)(ou\; g_{31}(a_3)) = 3 + 4 = 7$$

Thus, it is only because that:

$$U_3\big(g_1(S_1), g_2(S_2), g_3(S_3)\big) = U_3(4,10,7) < U_3(4,8,7)$$

hat strategy that promotes 1, $(b_3, e_3)$is chosen rather than the strategy a_3.

Remark2 :

Coalition between players 1 and 3 must be based on a particularly binding cooperation agreement to induce Player-1 to overcome player-2's credible threat and it associated risk. Indeed, if Player-3 does not hold its commitment and plays strategy a_3 rather than $(\mathrm{b}_3, \mathrm{e}_3)$, the player's 1 payoff becomes then :

$$G_1 = g_{1(1,2)} + g_{1(3,1)} = g_1(b_1, d_1) + g_1(a_3) = 0 + 0 = 0$$

Thus, facing this lack of confidence, player 1 will it tempted to yield to the credible threat of Player 2. So the Nash of equilibrium of the system without commitment binding (binding agreement) will be:

$S_{N1}^* = (a_1, (b_2, c_2), a_3)$or,

$S_{N2}^* = \big(a_1, (b_2, c_2), (b_3, e_3)\big)$, if 3 waives "punishing" player 1.

The gains associated with these strategies are then the following

$$G_1(S_{N1}^*) = g_{1(1,2)} + g_{1(3,1)} = g_1(a_1) + g_1(a_3) = 1 + 0 = 1$$

$$G_2(S_{N1}^*) = g_{2(1,2)} + g_{2(2,3)} = g_2(a_1) + g_2(b_2, c_2) = 7 + 3 = 10$$

$$G_3(S_{N1}^*) = g_{3(2,3)} + g_{3(3,1)} = g_3(b_2, c_2) + g_3(a_3) = 3 + 4 = 7$$

Remark 3

The Nash equilibria defined in note 2 are the same as for a game that would not have been played sequentially but simultaneously. This results from the fact that the agreement is not sufficiently credible.

3. Conditions of cooperation

The credibility of the cooperation can be achieved in one of two ways. The first one is based on the extension of the game to a relationship between player 1 and player 3. In this case, the relationship will be of the type (1.3) as described in figure 4. This figure is an extension of the game between two players where the playing order is reversed in the sequence. (This can be another part of trade between the two countries. But, this time, it would be Player-1 that would have the opportunity to play first).

The second way starts from the remark that the relationships between States extend in the long term. By extension, the game looks like can a repeated game. This hypothesis is somewhat simplistic but acceptable considering the nature of trade relations that relate to energy, agri-food goods, manufactured products, etc. are dependent on the population growth, the consumption patterns, past trade agreements. It follows that from one year to another, the volume and the structure of bilateral trade evolve shortly (for example, the gas and oil imported into China from the Federation of Russia does not suffer variation of high-amplitude). This repetition in trade does not prevent the opening of new opportunities (new contracts and partners for example) but later in the statement, by assumption, we consider that gain matrices remain identical.

a) Extension of the game

As mentioned above, we consider that players 1 and 3 develop exchanges characterized by the fact that Player-1 plays first. We can easily see that following this pattern, Player-1 may effectively threaten Player-3 playing strategy b_4. Without more, it appears that threatening 3 will deter it to break the agreement concluded with Player-1. The Nash equilibrium of the game and the associated payouts are then:

$$G_1 = g_{1(1,2)} + g_{1(3,1)} = g_1(b_1, d_1) + g_1(b_3, e_3) + g_1(a_4, d_4) = 0 + 7 + 8 = 15$$

(refusalfrom Player1 to yield to the credible threat made by Player-2):

$$\mathrm{G}_2 = \mathrm{g}_{2(1,2)} + \mathrm{g}_{2(2,3)} = \mathrm{g}_2(\mathrm{b}_1, \mathrm{d}_1) + \mathrm{g}_2(\mathrm{b}_2, \mathrm{c}_2) = 5 + 3 = 8$$

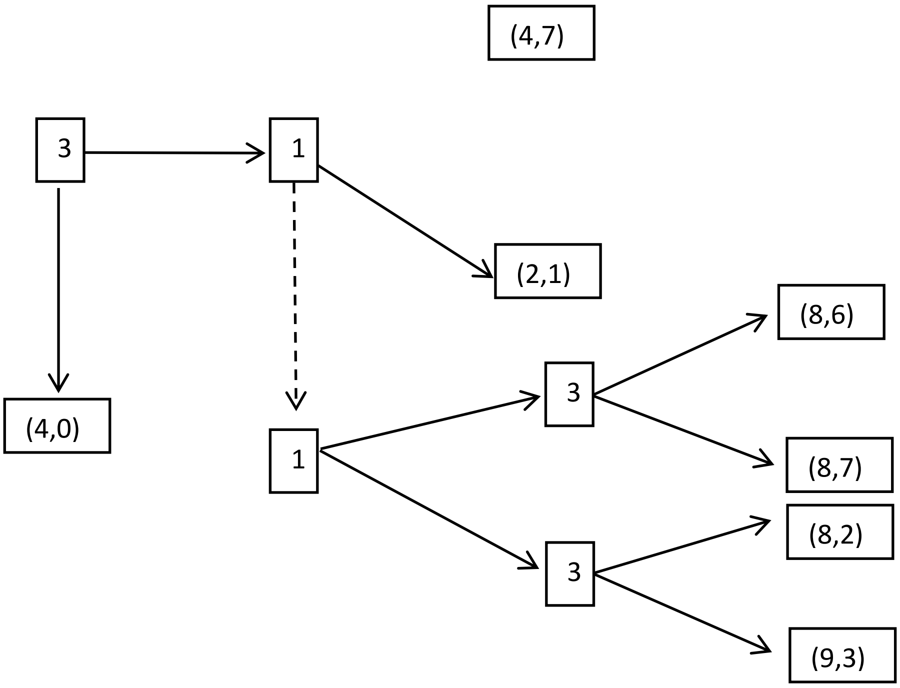
$$\mathrm{G}_3 = \mathrm{g}_{3(2,3)} + \mathrm{g}_{3(3,1)} = \mathrm{g}_3(\mathrm{b}_2, \mathrm{c}_2) + \mathrm{g}_3(\mathrm{b}_3, \mathrm{e}_3) + \mathrm{g}_3(\mathrm{a}_4, \mathrm{d}_4) = 3 + 4 + 7 = 14$$

Hence, Player-1's threats of playing strategy $b_4$in case of deviation from Player-3 when playing the game (3.1) is sufficient to encourage this last one not to deviate. We can evaluate the gains from a deviation. Hence, if for instance players 1 and 3 deviate:

$$G_1 = g_{1(1,2)} + g_{1(3,1)} = g_1(a_1) + g_1(a_3) + g_1(b_4, f_4) = 1 + 0 + 9 = 10$$
$$G_2 = g_{2(1,2)} + g_{2(2,3)} = g_2(a_1) + g_2(b_2, c_2) = 7 + 3 = 10$$
$$G_3 = g_{3(2,3)} + g_{3(3,1)} = g_3(b_2, c_2) + g_3(a_3) + g_3(b_4, f_4) = 3 + 4 + 3 = 7.$$

It is obvious that the deviation is not an option. Indeed, the gains of the deviant coalition are: $G_1 + G_3 = 17$while without deviation, the coalition wins: 15 + 14 = 19. In addition, deviating leads to strengthen the Player-2's position, then the players 1 and 3 see their satisfaction level increased. Adding a game sequence leads both players 1 and 3 players to adopt cooperative choices. The structure of game more than the prior agreement leads to focus on cooperation.

Figure 4



b) Repeated game

In arepeated game, the equilibriumdefined inremark 2cannot beconsidered alasting equilibrium. In the contextof this articlethe developments relatingto the repetition ofgameswill be discussedsyntheticallyand notanalytically.This choice is due not only toreasons of space, but also bythe need clarifyingthe analyticalconsequences of gamesmadebetweenthese specificplayers that are theStates.Thus, unlike thestandard approachesof repeated games theory, equilibrium made with mixed strategieshere have nomeaning.Indeed, a government cannotrandomly chooseamong severalstrategies.The strategiesare not simultaneous playedbutsequentially. In addition,the game's storyis importantso thatrepeated gamesarein closed loop.Furthermore, itis unrealistic to assumethat the samegain structureis repeatedendlessly.Also,the time intervalis itfixed.

In a repeated game, the issue of the threat involves applying sanctions corresponding to punitive strategies (case of repeated prisoner's dilemma) this in the aim at forcing players to use cooperative strategies. Thus, the equilibrium solution that appears in remark 2, is acceptable only for a game played only once. Here, repeating the game (without the extension proposed in the last section) is sufficient to ensure the coalition stability. Indeed, repeating $\mathrm{S}_{\mathrm{N}1}^{*}$ will lead in the long run to deplete players' 1 wealth and strengthen the player-2's position and this is contrary to the utility of both players 1 and 3. Moreover, considering the international relationships, repairing an agreement that has been broken cannot be made by accepting the penalty and the return to the 'good' strategy. Trust is paramount. Indeed, a single failure is sufficient to call into question the partners' good faith and a State cannot afford to rebuild confidence to the one who breached the agreement. Thus, in the framework of a repeated game, the only acceptable strategy is the strategy S_E^*. We remind that this strategy requires to 1 to override the Player-2's credible threat by virtue of the cooperation agreement passed with the player 3.

4. Economic and geostrategic implications in conclusion

This article highlights the importance of the use of credible and non-credible threats. Its main lesson is that cooperation is even stronger when based on long-term relationships which makes failures implausible. It reasonably well describes the relationships that exist between the Russian Federation and China (players 1 and 3), player 2 for example being Europe. Obviously, one may object that the United States are missing from the picture. In fact, adding a fourth partner would not have changed the global framework of the game but would have add in complexity.

All in all, international relationsships analysis can usefully be studied in terms of classical game theory. However, this approach needs adaptations of standard game theory. Indeed, t these games are sequential and they mainly accept pure strategies as solution of the game but not mixed strategies which are non sense in this context. However, mixed strategies can be conceived in the cases of armed conflict. To conclude, even if not developed, the spirit of GO game motivated our paper in which cooperation between two players does not exclude competition. Players 1 and 3 of our representation understood that they could not permanently exclude on each other from the international scene. Then, they preferred delineate areas that give them the highest possible benefits. In the simple model we gave, Player-2 bears the brunt of this agreement.

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